Radiology CME on the Web Using Secure Document Transfer and Internationally Distributed Image Servers

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We describe the implementation of a World Wide Web-based Continuing Medical Educational (CME) program in Diagnostic Radiology which allows accumulation of Category I credit. The program implements an unknown case presentation format which includes multiple choice questions, didactic information, and literature references with links to abstracts. Physician participation is anticipated to occur in brief sessions during which the program automatically tracks CME credit accumulation. To allow an interactive presentation, HTML electronic form documents are created "on the fly" by a Common Gateway Interface (CGI) application interfacing with several relational databases. The system is scalable with bandwidth intensive image transfers distributed over multiple internationally distributed image servers. For CME participants, the system utilizes document encryption to ensure confidential physician interactions.

INTRODUCTION

Continuing Medical Education (CME) would seem an ideal application for the capabilities of the World Wide Web. Medical practitioners may not be conveniently situated to major medical centers and the time needed to attend regularly scheduled CME activities may become a luxury in the context of the managed care environment. A web-based CME activity could provide a convenient method for physician self-education. In addition, hyper-links could integrate diverse on-line medical resources such as medical literature, treatment protocols, or clinical practice guidelines.

We describe the implementation of "Internet CME" in which we specifically address issues we believe essential for successful Internet-based instructional delivery to practicing physicians. These include to provide a secure method for self-assessment, implement a scalable network architecture, accommodate international participants, and finally to automate the system to conveniently deliver instruction at any time and anyplace around the globe.

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METHODS

The "Internet CME" project is an outgrowth of an earlier project called "Virtual MRI".[1] Using an unknown case format, the participant is first presented with patient history and selected diagnostic images. A diagnosis is entered and the correct diagnosis is then revealed. As a self-assessment exercise the program does not assess the participant's diagnosis but does record it in a database. For objective assessment, four multiple choice questions are displayed. These are answered, automatically graded, and the answers revealed accompanied by didactic information and literature references. Continuing medical education participants must answer three of four questions correctly in order to receive credit for the case presentation. If less than three questions are correctly answered, the participant can study the didactic information to re-answer the questions and obtain credit.

The case presentation format is expected to allow the user to complete an entire case presentation in about twelve minutes. This includes successfully completing questions, reviewing didactic information, and literature references. Although it is expected that a participant would complete only one or two cases in a given session, the user is not limited in the number of cases which could be viewed in a given session. Credit for viewing a specific case is automatically recorded by the Common Gateway Interface (CGI) application. CME credit for a specific case is awarded only once.

The instructional network consists of a central server located in the United States implemented on a Apple Power Macintosh 7500 with Ethernet access to the Internet via a T3 connection. The Hyper Text Transfer Protocol (HTTP) server software is Quarterdeck's WebSTAR (non-secure) and WebSTAR/SSL (secure). Currently, both the secure and non-secure servers are implemented on the same computer. In the future, if demand warrants, the central server functions could divided between several computer servers. The CGI application was implemented with AppleScript. The CGI interacts with several Filemaker Pro 3.0 databases to create the HTML documents. Current databases include case data, registration data, and user tracking data.

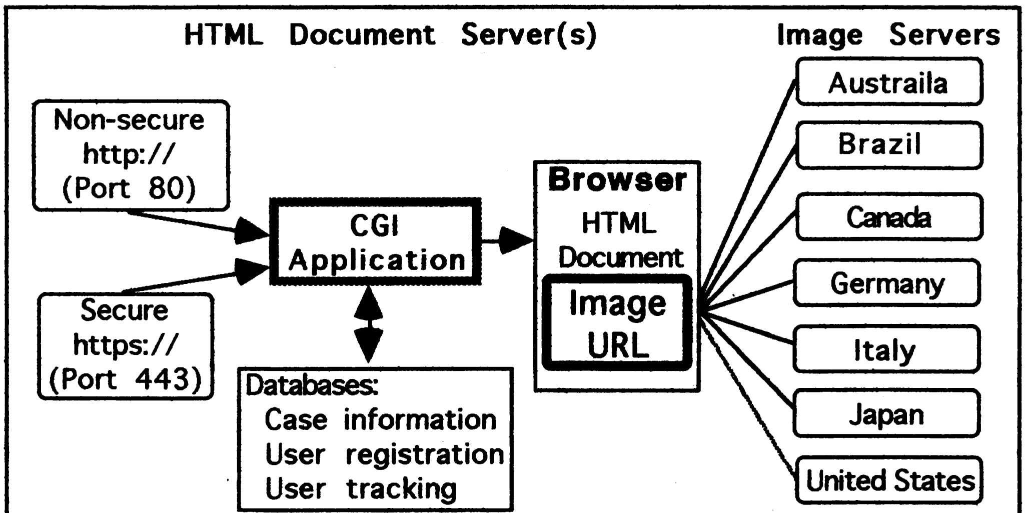

Figure 1. Model for distributed World Wide Web servers consists of a central document server which utilizes a CGI application to create HTML documents which reference images on globally distributed servers.

For CME subscribers, public key encryption techniques provide "secure" documents for confidential interactions both during the instructional program and registration. Currently, complementary subscribers interact through non-secure documents. Although the server HTTP software supports 120 bit private keys (military grade encryption), federal regulation limits current client software (Netscape) to private keys of 40 bits (industrial grade encryption). A discussion of encryption techniques is beyond the scope of this manuscript.

While the central server is responsible for HTML document creation, a global network of image servers distributes the project's images (Figure 1). The central server creates HTML documents which reference images on a specific image server. The specific image server employed depends upon the participant's registration information (discussed below). The image server network currently consists of seven servers located in Australia, Brazil, Canada, Germany, Italy, Japan, and the United States. However, only the central image server in the United States supports the transmission of encrypted images.

Maintenance of the image server network is facilitated through a specially created "drag and drop" application through which all images are automatically transferred via FTP to remote servers. Some sites have allowed password protected FTP access to the same folder publicly available by the HTTP protocol. Other sites have established a password protected FTP folder distinct from the public HTTP folder. For these sites, an e-mail message is automatically sent to the server administrator with notification that additional images have been delivered to the FTP folder. For most clinical cases, the images are transferred to the remote site approximately two weeks in advance of public case release to provide for vacations or other unavailability of the remote webmasters.

All participants must complete a registration form for either a CME subscription or complementary subscription (no CME credit). The registration process is completely automated by the CGI application. Complementary subscribers provide an e-mail address, age, and geographic location. These are automatically stored in a registration database. The availability of the e-mail address provides an efficient mechanism for future user notification regarding the availability of new cases.

CME credit is available though paid subscription. More complete demographic information is requested as a requirement of the medical school's CME office. This includes name, address, phone number, and e-mail address. Both check and credit card payment options are available. When electing payment by check, once registration is complete, a registration document is sent to the client computer which is printed and returned with the check by standard mail. Credit card information is collected both electronically via secure protocols and non-electronically via mail, fax, or a toll free number. Currently, credit card numbers are processed manually. However, we anticipate automatic processing of credit card numbers in the future.

RESULTS

International Image Servers
To our knowledge a system incorporating this unique international server arrangement has not be previously described. The model employs a central server with seamless integration of multiple remote image servers. This process occurs unbeknownst to the user with a document with images from Japan looking the same as images from Australia. The model attempts to overcome bandwidth limitations which restrict the capabilities of the Internet to distribute case material. According to colleagues in other countries, while links to their local area are efficient, international links can be slow especially for images. This implementation of geographically distributed servers attempts to overcome overcrowded international links.

Document encryption
This project successfully integrates encrypted document transmission for both registration and interactions of CME subscribers. There is no difference in how the presentation is displayed on the client computer for encrypted compared to non-encrypted documents. In utilizing encrypted documents, the CME participant is assured a level of security such that interactions with the program are completely confidential.

Document encryption requires server capability to create encrypted documents and client software enabled to interpret them. Not all client software is capable of interpreting encrypted documents. During early testing it was discovered that both the HTML and images must be encrypted for correct display. In the current implementation, the international image servers are non-encrypted.

Secure and non-secure Internet CME program versions run in parallel on the central server. Parallel program versions were adopted to allow the widest possible audience of participation. While encrypted CME is available, non-secure access is available for those participants without an secure browser or for those who elect non-secure interaction. During testing it was determined that there was no difference in perceptible server performance of secure verses non-secure transmission.

Server security
Server security is a consideration from both internal and external sources. Keeping the main server safe from Internet hackers is most important. It is manditory to protect the integrity of both the case database and the demographic information including payment information. A security breech has never be reported on the Macintosh platform using WebSTAR software. The directory containing the program databases is distinct from the directory which is accessed by the web server. Internal security is also provided in that the server computer is located in a secure area and has software in place which password protects the project databases from direct access.

DISCUSSION

A feature of the Web is for client software to display text documents and include images. The Internet location of the images is specified as Uniform Resource Locators (URL) in Hypertext Markup Language (HTML) coding. An important aspect of the World Wide Web is that images needed to display a given HTML document do not have to be located on the same server from which the HTML document originated. In HTML documents, the relative size of the HTML coding is small (usually <3k bytes in our program) compared to the size of the images (usually 60k bytes in our project). In the single server model the user must retrieve both of these from the same geographically remote server.

A simple solution to improve access is the deployment of "mirror servers" with duplicate copies of both HTML documents and images. However, an interactive project cannot rely upon such an arrangement. The HTML documents in our application are created "on the fly" by CGI scripts interacting with relational databases. However, images needed to complete the retrieved HTML documents can be mirrored. In this model a participant in Australia directly interact with the central server in the United States. However, the HTML document sent from the server to the client references images already on a server in Australia. This speeds access for the international user in that the larger image is obtained from a local server. From the user's perspective there is no difference in the appearance of the document displayed.

This presented model of distributed image servers is scalable to allow incorporation of great number of image servers. It could be adapted to a number of current image intensive projects. System scalability at the outset is important as it will ensure successful long term viability for the project. Currently, in the United States, the system consists of a central HTML server and a single image server. However, this could easily be expanded to involve multiple image servers in the United States. The demographic information already collected regarding location of users could effectively guide the placement of these future servers.

In our application, we purposely limit the image size to 60 kB to allow the average user with a 14.4 kB modem to transfer images in less than one minute 28.8 modem transfer thirty seconds). We acknowledge that authors have noted that educational users will not tolerate an image load time of greater than twenty seconds.[2] However, rather than viewing multiple cases for an extended period of time, we anticipate that our typical participant will integrate case viewing into their "web surfing". In this context, waiting for an image to load should not be met with the same intolerance as if the user were viewing dozens of cases in a single sitting. Formative assessment is planned to determine if our assumption regarding users interactions is correct.

A consideration for scalability also relates to the project being able to handle a situation where all users are high bandwidth. For the world wide web, the HTML text is small compared to the size and number of included images. The current model anticipates the size of HTML documents to remain relatively constant but the quality and size of medical images to increase. With distribution of images to numerous servers, the capability of the present project to migrate to improved image displays and ever increasing bandwidth requirements is assured. The ultimate model which could be accommodated with our image server configuration is for the images to reside on a CD-ROM loaded on the user's computer. This model has already been successfully tested in our laboratory.

Physician confidentiality in interacting with self-assessment CME activities is an important issue. There is a the potential for unauthorized credit card purchases from credit card numbers stolen from non-secure Internet transactions. In reality the financial risk of unauthorized transactions is a more a concern for the credit card companies. However for the physician, a much greater risk to financial security would result from an unauthorized third party monitoring interactions with a self-assessment CME activity and possibly using this information to the detriment of that physician's career.

Whether Internet access to CME materials becomes a preferred method for physician education is an open question. Numerous at home self-educational materials are already available. There will likely be a novelty factor associated with Internet-based projects and repeated participant usage will depend more upon the quality of case presentations rather than the fact that the cases are available on the Internet. It is our hope that high quality presentations and the convenience of the Internet will sustain this project's future viability.

CONCLUSION

Through the implementation of the Internet CME project we have demonstrated the feasibility of a globally distributed image medical educational application. The current project is scalable and anticipates the incorporation of additional image servers. As bandwidth considerations become less an issue it is hoped that this international collaboration becomes the basis for the initiation of future global education projects. The project provides a model for physician education at any time, at any place in the world.

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